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RADIOCOMMUNICATION METHOD, TERMINAL AND RADIO UNIT AND TERMINAL ADAPTED FOR SAME

This invention relates to the control of radio links in a radiocommunication system. It concerns more specifically power adaptation for certain radio links capable of modifying transmission conditions for high speed data transmission radio channels.

Power control procedures for radiocommunication systems are well known, such as GSM ("Global System for Mobile Communications") or the UMTS (Universal Mobile Telecommunication System). Their purpose is to improve reception performances of data transmitted while simultaneously limiting the risk of interference.

Power control is particularly sensitive when it is applied to data transmission channels allowing a high speed, as very low power on such channels may lead to a high error rate in the transmission which is detrimental to the speed offered. This is also the case for channels giving feedback data concerning high speed channels, since transmission of such channels with too low a power may lead to incorrect interpretation of the feedback data which is likely to affect the useful speed over the high speed channels.

The UMTS proposes a high speed data transmission functionality termed HSPDA ("High Speed Downlink Packet Access"). A description of the complete functionality can be found in the technical specification 3GPP TS 25.308, Release 5, version 5.0.0, published in September 2001 by the 3GPP ("3rd Generation Partnership Project").

The HSDPA provides the use of shared downlink channels, termed HS-PDSCH ("High Speed - Physical Downlink Shared Channel"), allowing a base station to send high speed data to terminals. In response to reception of data sent over these channels, the terminals return feedback data to the base station, specifically acknowledgments and indications linked to the quality of the downlink channels over dedicated uplink channels, termed HS-DPCCH ("High Speed - Dedicated Physical Control CHannel").

The standard provides that a HSDPA transmission to a given terminal shall be possible only if there is a pair of dedicated uplink and downlink channels of DPCH type ("Dedicated Physical CHannel") between the network

and this terminal. Each DPCH has a data sub-channel (DPDCH - "Dedicated Physical Data CHannel") and a control sub-channel (DPCCH, "Dedicated Physical Control CHannel"). In particular, the DPCCH carries control information for the transmission power in the opposite direction. Thus, each 666 μs time slot on the downlink DPCCH from a base station to the terminal (DL_DPCCH) carries TPC ("Transmit power Control") bits to control the power transmitted by the terminal on the uplink DPCH. The value of said TPC bit tells the terminal whether it has to increase or decrease its transmission power during the next 666 μs time slot on the uplink DPCH. The increment γ by which the power is increased or decreased is typically $\gamma = 1$ dB.

Incorrect decoding by the base station of the HS-DPCCH received from a terminal is notably detrimental to the HSDPA service, in particular leading to multiple repetitions of the data transmitted over the HS-PDSCH, and thus capable of triggering a significant decrease in throughput, contrary to the channel's objective.

To safeguard reception from the HS-DPCCH, the use of higher power over an HS-DPCCH relative to the DPCCH uplink (UL_DPCCH) is known. This is achieved conventionally by the use of a power offset between the HS-DPCCH and the UL_DPCCH, over which a terminal communicates, in favour of the HS-DPCCH.

However, this poses a problem when the communication over the DPCH is in macrodiversity, or "soft handover" (SHO) mode. This mode provided in particular in the UMTS system, allows the terminal to receive the same data over dedicated channels from more than one base station simultaneously, in order to improve the reliability and quality of reception. Base stations coming into use are then part of what is termed an active set. Moreover, transmissions from the terminal are received by the different base stations and then recombined to find the data sent more reliably.

In comparison, the SHO mode is not available for HS-PDSCH and HS-DPCCH channels, which only involve a single base station. If the communication is in SHO for the dedicated UL_DPCCH channel, power setting over said channel generally takes into account propagation conditions over all existing radio links with each base station of the active group. The terminal combines the TPC bits received from different base stations to

determine whether it has to reduce or increase the transmitted power. The arrangements for this are explained in section 5.1.2.2 of technical specification TS 25.214, version 5.0.0, "Physical layer procedures (FDD)", published in March 2002 by the 3GPP organisation.

If the power transmitted over the UL_DPCCH is set conventionally, to obtain the transmitted power over the HS-DPCCH by applying an offset relative to that of the UL_DPCCH channel may impair the quality of the transmission over the HS-DPCCH. Indeed, transmitted power thus adapted for the UL_DPCCH, and thus for the HS-DPCCH, takes account of the quality of reception of the UL_DPCCH by all the base stations of the active set and not only by the base station carrying the HS-PDSCH downlink channel. However, this base station may receive the signals sent by the terminal with a lower quality than those from other base stations of the active group.

It can therefore be that this base station claims a power increase (TPC = "+") which is not attributable to the TPC bits output from the other base stations in the active group. In this example, conventional power control would lead to an inappropriate decrease of the power transmitted over the UL_DPCCH. The HS-DPCCH, whose power is set, thanks to an offset relative to the UL_DPCCH, sees its power decrease again, as it was already considered as too low by the station in question. Thus, the DPCCH, and in particular the acknowledgments which it carries, risks being received with a significant error rate, which degrades the performance.

Moreover, the HS-DPCCH channel does not carry pilot bits, i.e. bits recognised by the receiving base station from which the latter is capable of demodulating a transmitted signal. These pilot bits carried by the UL_DPCCH channel allow the base station to demodulate the signal sent over the HS-DPCCH in good conditions. Thus, too large a fall in the power over the UL_DPCCH, initiated by good reception by the other stations of the active group, can degrade the decoding of the HS-DPCCH by the base station for which it is intended.

Having permanently increased transmitted powers over HS-DPCCH and UL_DPCCH channels would limit the problems cited, but would permanently degrade the overall performance of the system, in particular by creating interference. As the activity rate of the HS-DPCCH channel can be

low in some cases (the HS-DPCCH can only carry acknowledgment data and cannot receive any transmission during the HS-PDSCH's periods of silence), maintaining high power over the HS-DPCCH channels and above all the UL_DPCCH would therefore prove counter-productive.

Finally, it should be noted that between two transmissions over the HS-DPCCH, a high number of orders to reduce power (TPC = "-"), owing to an increment γ at each 666 µs time slot, could be made at the request of the base stations of the active group, whereas the base station carrying the HS-PDSCH had called for an increase in power. Thus, during the next transmission from the terminal over the HS-DPCCH, which might be delayed, the transmitted power might be too low to allow quality reception. Even if this new transmission is made with a power increased by an increment γ, the risks of errors on its receipt remain significant.

One object of this invention is to limit these harmful effects by increasing the reliability of reception of channels capable of influencing the throughput of high speed downlink transmissions.

Another aspect of the invention, in the HSDPA context, is to increase the transmitted power from the HS-DPCCH and UL_DPCCH channels by a value sufficient to allow the base station in question to decode the HS-DPCCH with satisfactory reliability, at the same time limiting this increase in the time.

The invention thus proposes a radiocommunication method in which an active set of transceivers from a cellular radio network communicate with a terminal according to frame structures subdivided into successive time slots, the method comprising the following steps:

- send from the terminal a first radio signal at variable power over a dedicated uplink channel;
- send from each transceiver of the active set, over a dedicated downlink channel, a second radio signal carrying, in each time slot, a first power modification command determined on the basis of the first radio signal as received;
- send intermittently a third radio signal to the terminal, over a shared downlink channel from a reference transceiver of the active set; and
- send intermittently from the terminal a fourth radio signal with variable power over an uplink signalling channel associated with said shared

downlink channel, to supply feedback data for sending of the third radio signal,

According to the invention, the terminal executes the following steps for each time slot of the dedicated downlink channels during a non-transmission period of the fourth radio signal :

- combine the first power modification commands received respectively from the transceivers of the active set in order to obtain a second power modification command for a corresponding time slot of the dedicated uplink channel;
- detect whether the first command received from the reference transceiver differs from the second command obtained; and
- set the transmission power of the first radio signal according to the second power modification command,

and the next step when the transmission of the fourth radio signal begins over the uplink signalling channel after said non-transmission period;

- set the transmission power of the fourth radio signal, taking into account the differences detected during at least one part of said period.

This method of setting the power of the fourth radio signal (the signal from the HS-DPCCH in the application to HSDPA) is used to optimise reception conditions for the reference transceiver (the one sending for the terminal over the HS-PDSCH). The method should take into account possible drift of the applied power setting compared to that which the reference transceiver claimed in the non-transmission period over the uplink signalling channel, drift due to the different commands which the other transceivers of the active set could have sent.

In one particular embodiment, the first radio signal carries pilot symbols to aid receipt of the signals sent by the terminal over the uplink channels. The first radio signal thus has its power controlled in a similar way to repeating the transmission over the uplink signalling channel, in order to allow satisfactory demodulation of the fourth signal.

Differences detected are typically taken into account in the setting of the transmission power of the fourth radio signal in the first time slot following the non-transmission period and in the setting of the transmission power of

the first radio signal in a time slot corresponding to the dedicated uplink channel.

The power of the first signal is optimised over the uplink channel outside the transmission periods over the signalling channel using the conventional power control procedure.

If the terminal continues to send the fourth radio signal after the first time slot following the non-transmission period, the transmission power of the first and fourth radio signals after said first slot is preferably set by applying the first power modification command received from the reference transceiver.

In a preferred embodiment of the method, the terminal stores, while the fourth radio signal is not being sent, the number of differences detected for the most recent K time slots for the dedicated downlink channels, K being a positive integer. Setting of the transmitted power of the fourth radio signal in the first time slot following the non-transmission period thus includes the application of a correction in dB proportional to the number of differences stored.

The method is well suited to situations termed "softer handover" (SerHO). In such a situation, several transceivers in the active set are part of a single unit (termed "node B" in the case of a UMTS network). The first signal sent by the terminal is sensed by these transceivers which produce flexible estimates of the information transmitted. These estimates are combined locally ("soft combining"), which allows the reception of the information to be optimised.

In general, transceivers in the active set forming part of the same unit in SerHO deliver identical initial power modification commands over their dedicated downlink channels.

If the reference transceiver, sending for the terminal over the shared channel, is part of said unit, it may be that it senses the uplink channels fairly weakly, as it sends power reduction commands because one or more of the other transceivers in the active set also forming part of the unit sense these uplink channels strongly, giving rise to good combined reception. In this case, the terminal will only be able to report that the reference transceiver in fact wants a power increase. This may result in poor reception of the uplink signalling channel associated to the shared downlink channel for the terminal.

This risk is advantageously avoided by activating the reception of the fourth radio signal in each of the transceivers in the active set forming part of the unit, and by combining the estimates thus obtained, unless it is necessary to report to the control device.

Thus, in one embodiment of the method, where a group of at least two transceivers in the active set, including the reference transceiver, belong to a single radio unit, and where a common initial power modification command is determined at each time slot to be sent by each of the transceivers in the group, based on versions of the first radio signal received respectively by the group's transceivers, the invention envisages that the radio unit activates reception of the fourth radio signal in each of the group's transceivers and combines the versions of the fourth radio signal received respectively by the group's transceivers to recover the feedback data.

The invention also proposes a radio unit for a cellular radio network using structures of frame subdivided in successive time slots for transmitting radio signals, comprising several transceivers which can be directed to join an active set of transceivers relative to a terminal. Each transceiver of the unit belonging to the active set is arranged for receiving a first radio signal sent by the terminal over a dedicated uplink channel and to send, over a dedicated downlink channel, a second radio signal carrying a command to modify the power in each time slot, the power modification command being determined jointly for the transceivers in the unit belonging to the active set by combining the versions of the first radio signal received respectively by said transceivers. Any one of the transceivers belonging to the active set can also be directed to send in isolation and intermittently a third radio signal to the terminal, over a shared downlink channel and to receive a fourth radio signal sent intermittently by the terminal over an uplink signalling channel associated with said shared downlink channel, the fourth radio signal supplying feedback data for sending of the third radio signal. The radio unit also including means to activate reception of the fourth radio signal in each of the transceivers of the unit belonging to the active set and means of combining the versions of the fourth radio signal received respectively by the transceivers of the unit belonging to the active set, to recover feedback data.

Another aspect of this invention relates to a radiocommunication terminal for communicating with a cellular radio network using frame structures subdivided into successive time slots for transmitting radio signals, comprising:

- means of sending a first variable power radio signal over a dedicated uplink channel addressed to an active set of transceivers in the cellular radio network;
- means of receiving second radio signals sent respectively over dedicated downlink channels by the transceivers in the active set, the second radio signal originating from a transceiver carrying, in each time slot, an initial power modification command determined on the basis of the first radio signal received;
- means of receiving a third radio signal sent intermittently by a reference transceiver in the active set over a shared downlink channel;
- means for the intermittent transmission of a fourth variable power radio signal over an uplink signalling channel associated with said shared downlink channel, to supply feedback data for sending of the third radio signal;
- means of combining the initial power modification commands received respectively from the transceivers in the active set for each time slot of the dedicated downlink channels during a non-transmission period of the fourth radio signal, in order to obtain a second power modification command for a corresponding time slot in the dedicated uplink channel ;
- means of detecting the differences between the first command received from the reference transceiver and the second command obtained during the non-transmission period of the fourth radio signal;
- first means of setting the transmission power of the first radio signal during the non-transmission period of the fourth radio signal, according to the second power modification command , and
- second means of setting the transmission power of the fourth radio signal when sending of the fourth radio signal starts over the uplink signalling channel after said non-transmission period, the second setting means being arranged for taking into account the differences detected by the detection means during at least part of said period.

Other features and benefits of this invention will become apparent from the description below of non-limitative embodiments and with reference to the attached drawings, in which:

- figures 1A and 1B are diagrams illustrating the frame structure employed over the dedicated traffic channels in the UMTS system in FDD mode;
- figure 2 is a system diagram implementing the invention;
- figure 3 is a diagram illustrating the principal radio channels involved in the invention;
- figure 4 is a schematic representation of the operations carried out by a terminal according to the invention if the transmissions over the HS-DPCCH channel are protracted;
- figure 5 is a schematic representation of the operations carried out by the terminal if transmissions over the HS-DPCCH channel are very close together; and
- figure 6 is a diagram of another system implementing the invention.

In this description, the invention will be described more particularly in its application (but not limitatively) to third generation radiocommunication networks of the UMTS type in FDD mode ("Frequency Division Duplex").

UMTS is a radiocommunication system using Code Division Multiple Access (CDMA), i.e. the symbols sent are multiplied by spreading codes formed from samples termed "chips", where the frequency (3.84 Mchips/second in UMTS) is greater than that of the symbols sent. The spreading codes distinguish different physical channels PhCH (Physical CHannel) which are superposed on the same transmission resource consisting of a carrier frequency. The auto- and inter-correlation properties of the spreading codes allow the receiver to separate the PhCH and extract the symbols sent to it. For UMTS in FDD mode on the downlink, a scrambling code is allotted to each cell and different physical channels used by this cell are distinguished by mutually orthogonal "channelling" codes. For each PhCH, the overall spreading code is the product of the channelling code and the cell scrambling code. The spreading factor (equal to the ratio between the chip frequency and the symbol frequency) is a power of 2 comprised between 4 and 512. This factor is chosen as a function of the symbol rate to be sent over the PhCH.

The modulation used over dedicated physical channels of the DPCH type is quadrature phase modulation (QPSK - Quadrature Phase Shift Keying). The symbol sequences sent to the modulator are thus composed of quaternary symbols, each consisting of a two bit assembly.

The DPCH conform to a frame structure illustrated by figures 1A and 1B. The 10 ms frames are follow one another on the carrier frequency used by the base station. Each frame is subdivided into N = 15 time slots of 666 μs. The lower diagram of figure 1A illustrates the contribution from a downlink DPCH (DL_DPCH) to a time slot in FDD mode, which comprises:

- a certain number of pilot bits PL. Known *a priori* by the terminal, these PL bits allow it to estimate some of the relevant signal demodulation parameters, in particular for power control;
- a transport format combination indicator (TFCI);
- a transmit power control (TPC) command to be used by the terminal over the uplink; and
- two data fields, termed DATA1 and DATA2, placed either side of the TPC field.

The DL_DPCH can thus be seen as bringing together a dedicated control channel, or DL_DPCCH, corresponding to the TFCI, TPC and PL fields, and a dedicated data channel, or DL_DPCCH, corresponding to the DATA1 and DATA2 fields, said data and control channels being time multiplexed.

In the uplink direction, two physical channels, UL_DPDCH and UL_DPCCH respectively, transport the data and control fields and are code multiplexed. More precisely, the complex baseband signal has a real part (QPSK channel 1) carrying the UL_DPDCH data and an imaginary part (Q channel) carrying the UL_DPCCH data, which includes the same type of information as the DL_DPCCH plus, optionally, feedback bits (FBI). This is illustrated in figure 1B.

Let us now consider the system represented in figure 2. It comprises three base stations 1, 2, 3 (or node B) serving the respective cells and communicating in SHO with a terminal 4 over dedicated channels as described above. This is illustrated in figure 2, where it can be seen that each base station 1, 2, 3 sends data to terminal 4 via a downlink channel

DL_DPCH_1, DL_DPCH_2, DL_DPCH_3. Terminal 4 in fact sends data via an uplink channel UL_DPCH.

The UL_DPCH sent by the terminal is received by each of the base stations with a view to recombining the signal sent in a radio network controller (not shown in the figure). In the opposite direction, the DL_DPCH_1, DL_DPCH_2, DL_DPCH_3 channels send the same data (except perhaps the TPC bits), which the terminal recombines to decode the signal with increased reliability. The base stations 1, 2 and 3 which communicate simultaneously with terminal 4 are thus part of what is termed an active set.

As mentioned in the introduction, a procedure for controlling the power transmitted by the terminal 4 over dedicated channels can be implemented. Insofar as the UMTS system is concerned, this is described in the aforementioned technical specification TS 25.214.

Consider the case of controlling the power on the control sub-channel UL_DPCCH, for which the terminal is in SHO. Each base station 1, 2, 3 belonging to the active group estimates a signal-to-interferer ratio (SIR_{est}) for the uplink channel UL_DPCCH. Each base station then compares the SIR value which it has estimated against a target value (SIR_{target}). Depending on the result of this comparison, each base station in the active group generates a TPC command and sends it by time slot over the DL_DPCCH addressed to terminal 4. The TPC command sent equals 0 (or "-" depending on the notation used) if the SIR value estimated by a base station in the active group is greater than the target value. Conversely, if the SIR value estimated by a base station in the active group is less than the target value, the base station in question sends the TPC command 1 (or "+" depending on the notation used) to terminal 4.

Terminal 4 receives in the corresponding time slot the different TPC commands coming from each base station 1, 2, 3 in the active group. It then determines a combined TPC command from the TPC commands received. According to a method provided by the standard, the result of this combination returns to a logical AND operation: the combined command equals 0 ("-") as soon as at least one of the base stations 1, 2, 3 in the active group has sent a "-" command for the corresponding time slot and 1 ("+") if all base stations in the active group have sent a "+" TPC command.

In a conventional embodiment of the prior art, an interval γ for increasing or decreasing the power transmitted by the terminal is defined. It is typically γ = 1dB. The terminal transmitted power over its UL_DPCCH is then matched by taking into account the value of this increment and the combined TPC command. Thus, if the combined TPC command is "-", the transmitted power is reduced by γ. If the combined TPC command is "+", the transmitted power is increased by γ.

The standard provides a different setting for the transmitted power of the terminal on sub-channels UL_DPDCH and UL_DPCCH. The gains β_d and β_c calculated or signalled by the network are applied to this pair of sub-channels respectively (section 5.1.2.5 of the aforementioned technical specification TS 25.214).

The next case to consider is the use of the HSDPA functionality mentioned earlier. The HSDPA allows a base station to transmit data at high speed for a group of terminals situated in the area covered by the base station. It relies on a shared high speed downlink transport channel: the HS-DSCH (High Speed - Downlink Shared CHannel). In the FDD mode which is of more interest in this description, the main characteristics of this channel are:

(i) a 2 ms sub-frame corresponding to 3 × 666 µs time slots;

(ii) hybrid methods for requesting retransmission of HARQ (Hybrid Automatic Repeat reQuest) data; and

(iii) a link adaptation mechanism.

At access layer level, part of the medium access control (MAC) protocol layer, the MAC-hs, is located in the base station. This provides for high speed over this channel. For the same reason, the HS-PDSCH uses a relatively low spreading factor of 16. In a given cell and for a given scrambling code, up to 15 HS-PDSCH channels using orthogonal channelisation codes can be set up, with a single HS-DSCH assigned to a user.

The HS-DSCH transport channel is carried by a HS-PDSCH (High Speed - Physical Downlink Shared Channel). This channel does not support the SHO mode as the rapid transmission mechanisms assume communication with a single base station. In the example illustrated by figure

5, the HS-PDSCH, carrying data addressed to terminal 4, is sent by base station 1.

One or more specific physical shared control channels termed HS-SCCH (High Speed - Shared Control CHannel) must be provided for a HS-DSCH channel. The signalling data carried by the HS-SCCH identifies the target terminals for the blocks sent over the HS-DSCH, and provides them with a certain number of indications relevant to reception of these blocks:

- a transport format and resource indicator (TFRI), giving information concerning the format of the dynamic part of the HS-DSCH channel, in particular for the modulation scheme used and the physical resources assigned (channelisation codes):
- data tied to the HARQ protocol, in particular the redundancy version, a HARQ process identifier, and a new data bock indicator.

A HS-SCCH channel uses a spreading factor of 128, with a sub-frame identical to that of the HS-DSCH (3 time slots of 666 μs). All the HS-PDSCH sent by a base station are time-aligned and the synchronising of the HS-SCCH is advanced by two slots (1333 μs) relative to that of the associated HS-PDSCH, as illustrated in figure 3. This allows the terminal to which a block of data is sent over a HS-PDSCH in a HSDPA sub-frame of 2 ms to be aware of the data necessary for its reception. Some data contained in the TFRI, namely the codes assigned and the modulation used, are essential for the terminals as they allow demodulation of the HS-PDSCHs which concern them to start. This is why the TFRI data is included in the first time slot of each sub-frame on the HS-SCCH. Thus, rapid decoding of the HS-SCCH allows a terminal to read the HS-PDSCH content in the next sub-frame without any loss of information.

A dedicated uplink channel is also defined in the HSDPA functionality: the HS-DPCCH (High Speed Dedicated Physical Control CHannel). It allows the terminal involved in a HSDPA transmission to return the feedback data to the base station carrying the HS-PDSCH channel. This feedback data in particular includes the acknowledgements from the HARQ protocol and relevant measurements for the link adaptation.

In more detail, the HS-DPCCH uses a sub-frame structure whose duration is the same as that of a sub-frame, i.e. 2 ms, with a spreading factor

of 256. Each HS-DPCCH sub-frame is made up of a first field of 2560 chips (10 symbols) containing the HARQ protocol acknowledgments (field marked "ACK" in figure 3). The last 5120 chips (20 symbols) are not sent systematically to each sub-frame. If they are, they contain a field termed Channel Quality Indication (CQI) giving indications on the quality of the HSDPA downlink. The HS-DPCCH is not sent continuously. In particular this is the case in periods when no information is sent to the terminal over the shared HS-PDSCH channel.

Figure 3 gives a time representation of the main channels used between a base station 1 and a terminal 4 involved in a HSDPA call. After compressing and decoding the signal received over four HS-SCCH channels indicated at the terminal (of which only two are represented in figure 3), the latter identifies the HS-PDSCH channel over which the base station will optionally send it the data at high speed with an offset of two time slots. Said transmission is shown on the figure in time slots #0, #1 and #2.

Moreover, dedicated channels are also used: the DL_DPCH downlink channel offset relative to the HS-SCCH by a time τ_1 and the UL_DPCH uplink channel having a time offset T_0 corresponding to approximately 1024 chips, relative to DL_DPCH. Finally, for the HS-DPCCH uplink channel, the first sub-frame or time slot #0 of 2 ms is offset relative to the end of the time slot #2 of the HS-PDSCH. This offset equates to 7.5 time slots (i.e. 5 ms) to which is added a time adjustment τ_2 in order to maintain orthogonality between the HS-DPCCH and UL_DPCCH codes, said adjustment consisting of making the offset between these two multiple channels of 256 chips in duration.

In the example illustrated by figure 3, a second HSDPA transmission is indicated at the terminal by another HS-SCCH channel. It is marked with the time slot indices #3, #4 and #5. The transmission therefore takes place over a HS-PDSCH channel, which can be the same as for the first transmission, as is the case in figure 3, or even on one or more other HS-PDSCHs for the base station in question.

It should be noted that, in the example illustrated in the figure, the second HSDPA transmission is the subject of an acknowledgement over an HS-DPCCH sub-frame but that the CQI is not sent for this second

transmission. Moreover, the period of silence on the HSDPA downlink channels between the two transmissions represented implies a lack of transmission by the terminal in question over its dedicated HS-DPCCH channel, even if the terminal benefits from this silence to repeat the acknowledgment indications.

Owing to the presence on the HS-DPCCH channel of feedback data, in particular acknowledgments, concerning the data sent over the HS-PDSCH, reception by the base station supporting the HSDPA (base station 1 in figure 2) must be reliable, or it will cause repetitions of the data sent over the HS-PDSCH channel leading to a fall in speed contrary to the objective, or more generally a degradation of the HSDPA service. Power control over the HS-DPCCH must therefore be managed in order to limit reception errors by base station 1.

Moreover, the HS-DPCCH does not carry pilot bits. Base station 1 is used for pilot bits sent by terminal 4 over its dedicated UL_DPCCH channel to demodulate the signal sent over the HS-DPCCH if both channels encounter the same propagation conditions, with a slight time offset as well. Hence the pilot bits sent on a UL_DPCCH time slot allow base station 1 to demodulate the corresponding signal at the sub-frame of the HS-DPCCH channel when the transmission has started before the end of said UL-DPCCH time slot.

To receive the data sent over the HS-DPCCH reliably, it is relevant not only to send this channel's sub-frames with sufficient power, but also to send the UL_DPCCH pilot bits contained in the respective time slots immediately preceding the commencement of the transmission of these sub-frames with sufficient power to be capable of demodulating the HS-DPCCH correctly.

If we return to the example illustrated in figure 3, this means that, for example, not only the sub-frame ACK #0 of the HS-DPCCH must be sent with sufficient power, but also the UL_DPCCH time slot immediately preceding the start of the sub-frame ACK #0 of the HS-DPCCH, containing the pilot bits necessary to demodulate this sub-frame, i.e. the time slot marked "PL#0" in the figure.

According to the invention, the power control mode used on the UL_DPCCH and HS-DPCCH channels is similarly modified, in order that an offset can be applied to the transmitted power of a UL_DPCCH time slot to

obtain that of the corresponding HS-DPCCH sub-frame. Moreover, as the UL_DPCCH channel is capable of being on permanent send, even in the absence of any HSDPA transmission, the transmitted power on this channel cannot be set systematically to its maximum value, as might have been expected for the HS-DPCCH, where the transmissions are not continuous, as this would generate damaging interference to other communications.

It should also be noted that the transmitted power over the UL_DPDCH can vary in the same way as that over the UL_DPCCH, as this is provided in section 5.1.2.5 of the aforementioned specification TS 25.214.

The purpose of the HSDPA is to offer a high speed downlink. HSDPA channels are therefore set up for a base station 1 whose signals are received with satisfactory field strength at terminal 4. However, if the terminal is in SHO for the DPCH, it is not certain that at a given instant the base station 1 will be that which receives the signals sent by terminal 4 with maximum field strength.

This problem is illustrated in figure 4, where the line SB_i denotes the TPC commands sent by the base station i ($1 \leq i \leq 3$). TPC commands are then obtained following measurements made by the base stations on the dedicated uplink channel UL_DPCCH, as described earlier. To facilitate reading of the figure, the HS-DPCCH sub-frames have been aligned with the TPC commands sent to each UL_DPCCH time slot, as it will be seen that these could be slightly offset in time. This must be interpreted as meaning that a power change command for a UL_DPCCH time slot is also applied to the corresponding HS-DPCCH, i.e. the sub-frame which starts before the end of said time slot.

According to the example illustrated, it sometimes happens that SB_2 or SB_3 receives signals sent by terminal 4 with a level or more exactly an SIR_{est} greater than that estimated by SB_1. This means a "-" command for SB_2 and SB_3, whereas SB_1 sends a "+" TPC bit as the power which it receives from terminal 4 over the UL_DPCCH is too low ($SIR_{est} < SIR_{target}$), which risks preventing satisfactory reception of the HS-DPCCH data.

However, if the conventional power control algorithm as set out above is applied, this example culminates in a combined TPC command equal to "-", thus leading terminal 4 to decrease the power on its uplink channels once

again. However, between two transmissions on the HS-DPCCH channel, a number of differences may appear between the TPC and SB_1 commands and combined TPC commands, leading to successive falls in the terminal's transmitted power to the detriment of the quality of reception for the HS-DPCCH and UL_DPCCH at SB_1 level.

According to the invention, this imbalance is attenuated on repeating the transmission over the HS-DPCCH channel, i.e. as soon as a new acknowledgement is to be sent over the HS-DPCCH and as soon as the pilot bits to demodulate the signal containing said acknowledgement are sent over the UL_DPCCH.

To do this, when terminal 4 is not sending over the HS-DPCCH, it will store, as they are received, on a window of K values, where K is an integer, the values of the TPC commands received from SB_1 and the values of the combined TPC commands originating from the different base stations calculated by terminal 4 ("COMB" in figure 4). The number K of stored values may be fixed or variable, depending for example on the size of the memory available in terminal 4 or even the number of time slots separating two successive transmissions over the HS-DPCCH. The stored values are circled on the example illustrated in figure 4, where K has been set to a value of 6. They correspond to the last TPC values for SB_1 and COMB respectively, just before a new transmission on the HS-DPCCH channel, corresponding in the example to the sub-frame numbered N+1 in figure 4.

Comparison of these values one by one (i.e. for each time slot) by terminal 4 gives a number of differences between the TPC commands for SB_1 on the one hand and for COMB on the other. Hence the example in figure 4 shows two differences, i.e. two cases where the TPC bit is "+" for SB_1 but "-" for COMB as SB_2 has sent a "-" TPC bit for these time slots.

The UL_DPCCH time slot corresponding to the new transmission over the HS-DPCCH, i.e. the ACK field of the new sub-frame sent over the HS-DPCCH, is sent not with the power resulting from a COMB combined command, but with a power resulting from the command sent by SB_1 and increased by the number of differences detected on the observation window multiplied by a positive power increment δ (typically δ = 1 dB), where this increment can be the same as that for conventional power control (γ).

In this way, the time slot in question can be sent with a power closer to the demand from base station 1. The correction made to the transmitted power is thus $2 \times \delta$ dB + γ dB. The $2 \times \delta$ dB are linked to taking account of the differences detected and the γ dB are linked to the current TPC command sent by SB_1. Moreover, as the HS-DPCCH transmitted power is set in the same way as for the UL_DPCCH, at a close offset, the correction of $2 \times \delta$ dB + γ dB is also applied to the ACK sub-frame of the HS-DPCCH.

In one embodiment, $\delta = \gamma$, even if in the preceding example the power increase for the time slot in question is $3 \times \gamma$ dB. This power increase is illustrated in figure 4 by the value "+++" for the resultant power command applied by the terminal (RES line) for the corresponding time slot. However, other values of the parameter δ can be envisaged.

In another embodiment, for example, $\delta = 2 \times \gamma$ is chosen. This choice is used to compensate exactly the power loss effected by applying the COMB combined TPC commands, if SB_1 has asked for a power increase. In fact, if during a non-transmission period over the HS-DPCCH, SB_1 sends a "+" TPC, whereas COMB is "-", the command actually implemented by the terminal is "-", i.e. a decrease of γ dB. In the absence of SHO, SB_1 would have increased its power by γ dB. Therefore, the difference between the power requested by SB_1 and that actually applied is $2 \times \gamma$ dB. To compensate for this difference when repeating the transmission over the HS-DPCCH, a correction equivalent to $2 \times \gamma$ must therefore be applied.

After the power has been increased, the SB_1 TPC commands are applied to the uplink channels. In fact, the power deficit having been attenuated, or even compensated, over the first time slot (ACK) of the new transmission over the HS-DPCCH, it suffices for terminal 4 to match the power as commanded by SB_1 to send subsequent time slots (CQI) to comply with the transmission error rate desired by SB_1. This is illustrated at the end of the RES line in figure 4, on which are recorded the power variations actually applied by terminal 4 over the two time slots ("+" and "-" respectively). These are identical to those requested by SB_1 in its TPC commands.

Between two transmissions on the HS-DPCCH channel, for example the sub-frames numbered N and N+1 in figure 4, it is standard practice to apply combined TPC commands to vary the power over the corresponding

UL_DPCCH time slots. In figure 4, there is the sequence "- + - + - - - + -" for the first three time slots represented on the RES line, as on the COMB line.

Another embodiment is illustrated by figure 5, where transmissions over the HS-DPCCH channel (N and N+1 sub-frames) are closer together in time than in the preceding case. In this case, the observation window to be considered is reduced to K = 3, as shown for circled sequences on the COMB and SB_1 lines in the figure. In fact, during transmission of sub-frame N, the power was offset on the commands from SB_1 and only during the next three time slots, where the power is set by the combination (COMB) of the TPC commands are the differences between the COMB and SB_1 commands apparent.

In the example illustrated, only the first time slot has generated a difference even if the power command applied by terminal 4 is corrected by 1 × δ dB relative to the value resulting from the SB_1 command, over the first time slot on repeating the transmission over the HS-DPCCH. In the example, the corresponding TPC bit from SB_1 is "+" in order that the power is incremented by γ + δ dB compared with the power in the preceding UL_DPCCH slot ("++" value on the RES line in figure 5).

During the remainder of the transmission over the HS-DPCCH, the power variations applied (RES) by terminal 4 on the HS-DPCCH and UL_DPCCH channels only take into account TPC commands from SB_1, i.e. from the base station supporting the HSDPA channels.

Moreover, the HS-DPCCH N+1 sub-frame of the example illustrated in figure 5 is the subject of a repetition. This repeats two consecutive transmissions on the HS-DPCCH channel. In this case, the variations in applied power still conform to the TPC commands from SB_1. No power compensation is therefore necessary for the new acknowledgment (ACK), as any drift could only have occurred between these commands and the combined TPC commands since the last compensation. Neither is it essential that terminal 4 calculates the COMB combination of the various TPC commands received during the transmit period over the HS-DPCCH as it will not be used.

Finally, as in the preceding case, the COMB combined commands are again implemented by terminal 4 (see RES line) in order to modify the

transmitted power over the UL_DPCCH channel on completion of the latest transmission N+1. This is why the final three time slots represented in figure 5 incorporate a "-" sequence on both the COMB and RES lines.

In the preceding discussion, it was considered that each base station 1, 2, 3 served a network cell. In fact, the equipment termed "node B" in a UMTS network generally includes one or more transceivers to serve the respective cells, which are distinguished by different sets of spreading codes. In macrodiversity, it is current practice for several cells from the active group to depend on the same base station or node B. This is the SerHO case mentioned earlier.

As regards control of the power of the HS-DPCCH channel, the case where the reference cell, i.e. the cell tasked with sending HS-PDSCH over the shared channel(s) for the terminal, belongs to the same node B as one or more other cells from the active group must be examined.

This case is illustrated in figure 6, where terminal 4 receives simultaneously identical data from the three cells 11, 12, 13 depending on base station 10, or on the DL_DPCCH_{11}, DL_DPCCH2_{1} and DL_DPCCH_{13} channels. Terminal 4 combines the signals received from the three cells, which ensures a quality of reception better than that which it would enjoy by receiving information from only one of the cells.

In the uplink direction, terminal 4 sends data over a dedicated UL_DPCCH channel. The latter is received by the transceivers of the three cells 11, 12, 13. As has been described earlier, the UL_DPCCH channel contains pilot bits. Although the reception conditions for the uplink data are not necessarily the same for each cell, pilot bits sent are subject to joint measurement at base station 10. Hence TPC bits are evaluated globally by a base station 10.

Said TPC bits are sent to terminal 4 by each of the cells 11, 12, 13 over its respective DL_DPCCH channels. Terminal 4, for its part, produces a joint estimate of the received signals and deduces from these the TPC command to be applied.

The HS-PDSCH channel is sent only by a dependant cell of the base station 10, for example cell 11, and if said cell receives the UL_DPCCH sent by the terminal with a SIR lower than that for cells 12 and/or 13, it is possible

that the overall estimate of radio conditions by base station 10 may lead the latter to request a power decrease at terminal 4 (TPC = "-") although the UL_DPCCH is received weakly by cell 11. If the power offset between sending the UL_DPCCH and HS-DPCCH channels is respected, it is equally possible that the HS-DPCCH sent by the terminal will be incorrectly received by cell 11.

To mitigate this problem, the invention provides that in this case the communication over the HS-DPCCH shall also be in SerHO, insofar as this concerns the relevant cells from the same “node B” as that which sends over the HS-PDSCH. This means that the HS-PDCCH will be received by each of the transceivers 11, 12, 13 and then recombined at base station 10.

Terminal 4 has the "radio link set" concept (see section 5.1.2.2.2.2 from specification 25.214) allowing it to be aware that several radio links in SHO carry identical TPC bits, because they correspond to cells served by the same “node B” (SerHO case). It therefore considers the TPC bits output from cells 11, 12 and 13 as coming from a single base station, i.e. that they are combined by "soft combining" and that after combination they contribute to a single diagram line as in figures 4 and 5. The method described above for determining the power for the UL_DPCCH channels and, after applying an offset, the HS-DPCCH channels is applied as in the preceding case.

Thus, even if cell 11 receives the HS-DPCCH at a level much weaker than the others, the combined HS-DPCCH at base station 10 is compliant overall with the desired quality.